Quantum Computing with Electron Spins

Scientific Achievement

Utilizing low energy nitrogen ion irradiation, we have produced C_{60} with endohedral nitrogen. Raman and electron paramagnetic resonance (EPR) data from N@C_{60} demonstrate the stability of the C_{60} cage under nitrogen ion irradiation and the characteristic hyperfine splitting of the EPR line of N@C_{60}, respectively. We also demonstrate that the N@C_{60} can be separated from C_{60} and other impurity phases using high performance liquid phase chromatography. A presentation on this work was given at the *Materials Research Society Meeting,* Boston, MA, (Nov. 2005).

Significance

The development of an electron spin based solid state quantum computer will have profound influence on quantum mechanical calculations of physical phenomena, large number factorization, and large data base searches. A fundamental understanding of quantum coherence in molecular systems is a key to developing such a quantum computer. The production of high purity N@C_{60} is a major milestone for developing this material as a qubit. We plan to develop and implement two new experimental approaches for single molecule spin measurement: electron spin resonance-scanning tunneling microscope (ESR-STM), and a radio-frequency, single electron spin transistor (RF-SEST). These capabilities will enable novel studies of spin dynamics and quantum phase coherence.

We will also make use of biological processes to attach C_{60} to DNA. By using a DNA scaffold we will be able to precisely locate the qubits and have a precise separation of the qubits. C_{60} will be functionalized and attached to polynucleoamide (PNA). PNA forms a secondary assembly by molecular recognition of specific sites along double stranded DNA. The location will be controllable with exquisite 3.5A resolution, which is the thickness of a single base pair. Advanced dip pen nano-lithography techniques for address gates and tunneling leads to the C_{60}-DNA network will also be developed by Professor Dravid's group at Northwestern University.

Performers

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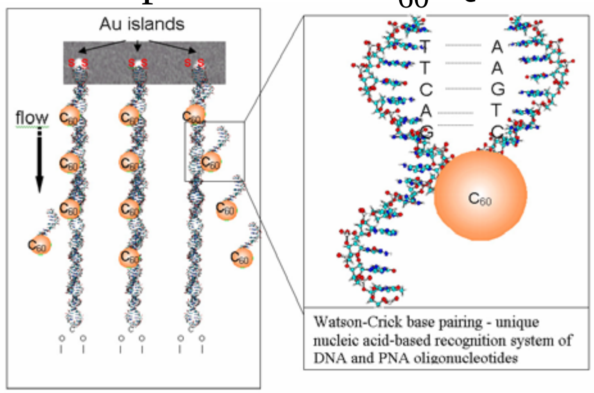
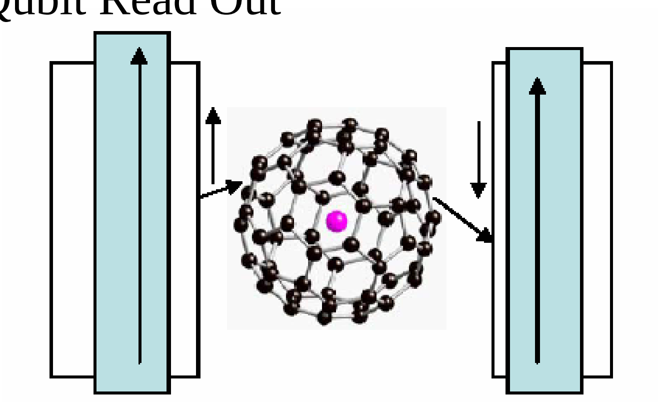
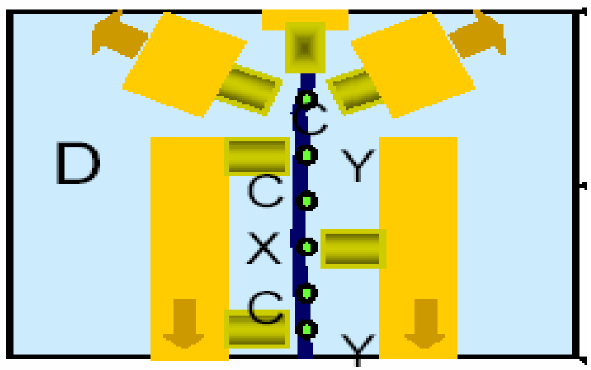
DNA Template for N-C_{60} Qubits



Radio Frequency Single Electron Spin Transistor for Qubit Read Out



Dip Pen Nano-lithography for Gates & Junction



Interdisciplinary Nanoscience:
confinement, complexity, bio-interfaces, directed self-assembly

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